UNITED STATES PATENT APPLICATION

USING THE WAVE SOLDERING PROCESS TO ATTACH MOTHERBOARD CHIPSET HEAT SINKS

INVENTOR

George Hsieh

of
Portland, OR, USA

Prakash Nama
Reg. No. 44,255
Schwegman, Lundberg, Woessner, & Kluth, P.A.
1600 TCF Tower
121 South Eighth Street
Minneapolis, Minnesota 55402

ATTORNEY DOCKET No. 884.462US1
Client Ref. No. P11292

USING THE WAVE SOLDERING PROCESS TO ATTACH MOTHERBOARD CHIPSET HEAT SINKS

Technical Field

This invention relates generally to printed circuit boards and components coupled therewith, and in particular relates to components that are to be coupled with the printed circuit board.

Background

Processors and related computer components are becoming more powerful with increasing capabilities, resulting in increasing amounts of heat dissipated from these components. Similarly, package and die sizes of the components are decreasing or remaining the same, which increases the amount of heat energy given off by the component for a given unit of surface area. Furthermore, as computer-related equipment becomes more powerful, more chips are surface-mounted to the printed circuit board, and more and more components are being placed inside the equipment or chassis which is also decreasing in size, resulting in additional heat generation in a smaller volume of space. Increased temperatures can potentially damage the components of the equipment, or reduce the lifetime of the individual components and equipment. In addition, some components are more susceptible to damage resulting from stress and strain occurring during testing, packaging, and use.

Heat sinks have been used to assist in dissipating heat from the processor and other heat producing components within a housing. However, the overall size of the heat sink is limited by the volume constrains of the housing, and the footprint and/or the size constraints. Heat dissipation has been increased by using fasteners such as mechanical clips, epoxy and/or glue, and/or rivets which physically hold a heat sink to the processor package mounted on a printed circuit board. For some heat sinks, spring-loaded fasteners are used to couple the heat sink with the heat producing components to enhance the heat dissipated from the heat producing components. However, such

fasteners require one or more additional final assembly process steps, which results in requiring additional manufacturing resources after all of the soldering steps are completed. These additional manufacturing steps increase the cost of providing a thermal solution to heat producing components such as chipsets.

Figures 1, 2, 3, and 4 illustrate conventional manners 100, 200, 300, and 400, respectively, of coupling the heat sink to heat producing components such as chipsets and/or microprocessors. Figure 1 illustrates using a mechanical clip 110 to couple the heat sink 120 to the heat producing component 130 mounted on a printed circuit board 140 to enhance heat dissipation from the heat producing component 130. Figure 2 illustrates using epoxy and/or glue 210 to couple the heat sink 120 to the heat producing component 130. Figure 3 illustrates using spring-loaded fastener 310 to couple the heat sink 120 to the heat producing component 130. Figure 4 illustrates using rivets 410 to couple the heat sink 120 to the heat producing component 130. All of these prior art techniques require one or more additional final assembly process steps, which increases the cost of providing a thermal solution to heat producing components. In addition, the prior art techniques illustrated in Figures 1, 3, and, 4 require substantial circuit board space to mechanically retain the heat sink in-place.

For the reasons stated above, and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for a low-cost technique that consumes substantially less circuit board space that the prior art techniques to provide a low-cost thermal solution to the heat producing components.

Brief Description of the Drawings

Figures 1, 2, 3, and 4 illustrate prior art techniques of coupling heat sinks to heat producing components mounted on a printed circuit board.

Figures 5, 6, 7, and 8 illustrate front elevational views of different example embodiments of the heat sinks according to the present invention.

Figures 9, 10, 11, and 12 illustrate the process steps for assembling an electronic device using the heat sinks shown in Figures 5, 6, 7, and 8 according to the teachings of the present invention.

Figures 13, 14, and, 15 illustrate the assembled electronic device using the process steps shown in Figures 9, 10, 11, and 12.

Figures 16 and 17 illustrate the coverage/wetting of the thermal interface material between the heat sink and the heat producing component after passing through the wave pre-heaters.

Detailed Description

In the following detailed description of the embodiments, reference is made to the accompanying drawings that illustrate the present invention and its practice. In the drawings, like numerals describe substantially similar components throughout the several views. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the present invention. Moreover, it is to be understood that the various embodiments of the invention, although different, are not necessarily mutually exclusive. For example, a particular feature, structure, or characteristic described in one embodiment may be included in other embodiments. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims, along with the full scope of equivalents to which such claims are entitled.

This document describes, among other things, a low-cost technique that consumes less circuit board space than the traditional means for providing the chipset thermal solution.

Figures 5, 6, 7, and 8 illustrate front elevational views of different example embodiments of the heat sinks according to the present invention. Figure 5 illustrates an isometric view of one example embodiment of a heat sink 500 according to the present invention. As shown in Figure 5, the heat sink 500 includes two mounting pins 510, and

a thermally conductive plate 520. In some embodiments, the heat sink 500 can include at least one mounting pin. The pins are adapted to be disposed through corresponding mounting holes in a substrate such that when the heat sink 500 is thermally coupled to a heat producing component, the pins 510 are disposed through the holes for soldering the pins 510 in the holes for mechanically attaching the heat sink 500 to a substrate during pre-assembly operation to provide a low-cost thermal solution. In some embodiments, the heat sink 500 can include multiple pins and corresponding multiple holes in the substrate.

In some embodiments, the pins extend beyond the plate 520 such that the pins 510 can be soldered when the thermally conductive plate 520 is thermally coupled to a heat producing component. The heat sink can be made from materials such as copper, aluminum, and other such materials suitable for dissipating the heat from the heat producing component. In some embodiments, the pins 510 can be soldered to the substrate using processes such as wave soldering, surface mount soldering, and other such soldering processes. In some embodiments, pins can comprise 2 or more wave solderable pins.

Figure 6 illustrates an isometric view of another example embodiment of a heat sink 600 according to the present invention. The heat sink 600 shown in Figure 6 is similar to the heat sink 500 shown in Figure 5 except that the heat sink 600 shown in Figure 6 further includes a heat exchange portion 610 disposed across from the pins 510. In some embodiments, the heat exchange portion 610 includes multiple fins that extend upward beyond the plate 520.

Figures 7 and 8 illustrate isometric views of other example embodiments of heat sinks 700 and 800, respectively, according to the present invention. The heat sinks 700 and 800 are similar to the heat sinks 500 and 600 shown respectively in Figures 5 and 6, except that the heat sinks 700 and 800 include 4 pins instead of the 2 pins shown in Figures 5 and 6. Also, the thermally conductive plate 710 is configured to include the 4 pins shown in Figures 7 and 8.

Figures 9, 10, 11, and 12 illustrate one example embodiment of methods 900, 1000, 1110, and 1210, respectively required for assembling an electronic device using

the heat sinks shown in Figures 5, 6, 7, and 8 to at least one heat producing component 130 mounted on a printed circuit board 140 according to the teachings of the present invention.

Method 900 as shown in Figure 9, begins with mounting a front side 930 of the heat producing component 130 to the substrate 140. The substrate 140 also includes multiple holes 950. In some embodiments, mounting the heat producing component 130 includes electrically and/or mechanically coupling the component 130 to the substrate 140. The heat producing component 130 includes integrated circuit devices such as a chipset, a microprocessor, a digital signal processor, and/or an application-specific integrated circuit device.

Method 900 as shown in Figure 9 also includes positioning a layer of thermal interface material 910 on to a back side 940 of the heat producing component 130. The back side 940 of the heat producing component 130 is disposed across from the front side 930. In some embodiments, the thermal interface material 910 is either a phase change thermal interface material such as Chomerics T725, Chomerics 705, Chomerics 710, and/or Chomerics 454, or a thermal grease such as Thermalloy TC1, Shinetsu G749, and/or Shinetsu G750. While the thermal greases such as Shinetsu G749, and Shinetsu G750 are in liquid (*viscus)* form at room temperature, the phase change thermal material such as Chomerics T725, Chomerics 705, Chomerics 710, and Chomerics 454 are in a soft solid paste form at room temperature that melts with heating. These thermal interface materials melt when the active device such as the heat sink it is mounted on is heated at the wave-soldering temperatures. Generally, the phase transition (changing from a paste like state to a liquid state) temperatures of these phase change thermal interface materials are around 55^0C - 65^0C. Typically the ambient temperatures inside the wave soldering machines (around the pre-heaters and the solder wave chambers) are well above 70^0C. Temperatures above 70^0C are generally sufficient to melt the above-mentioned phase change thermal interface materials. Method 900 is compatible with use of either of the above-mentioned thermal interface materials.

Method 900 as shown in Figure 9 further includes aligning a heat sink 600 including at least one mounting pin 510 over the thermal interface material 910 and

further through the corresponding at least one hole 950 in the substrate 140 so that the pins 510 can be wave soldered to the substrate 140. It can also be envisioned that the pins 510 can be designed to be soldered to the substrate 140 using other circuit board assembly techniques such as pin-in-paste, surface mount, and other methods suitable for attaching the heat sink 600 to the heat producing component 130 during pre-assembly operations.

In some embodiments, the heat sink 600 is formed to include a thermally conductive plate such that the pins extend beyond the plate. In some embodiments, the heat sink is formed to further include a heat exchange portion 610 which extends beyond the plate. The heat exchange portion 610 is formed such that the heat exchange portion 610 is disposed across from the heat producing component. In some embodiments, forming the heat exchange portion 610 includes forming multiple fins that extend away from the plate. The heat sink 600 is made from materials such as copper, aluminum, and other such materials suitable for dissipating heat away from the heat source.

Method 1000 as shown in Figure 10, includes reducing the viscosity of the thermal interface material 910 by preheating 1010 the thermal interface material 910 in a wave soldering preheater to cause the thermal interface material 910 to wet the component to thermally couple the heat sink 600 to the heat producing component 130. In some embodiments, the reducing the viscosity of the thermal interface material 910 further includes loading the substrate including the heat producing component, thermal interface material, and the heat sink on to a conveyor of a wave soldering machine and reducing the viscosity of the thermal interface material by preheating 1010 the thermal interface material disposed between the back side 940 of the heat producing component 130 and the heat sink 600 such that the thermal interface material 910 melts and wets sufficiently the back side 940 and the heat sink 600 to provide sufficient thermal coupling between the heat producing component 130 and the heat sink 600. In a typical wave soldering machine, the thermal interface material 910 is exposed to temperatures of more than 70^0C for a period of 15 to 25 seconds over the pre-heaters, and further the thermal interface material 910 is exposed to temperatures above 80^0C for a period of 8-

12 seconds over the solder wave. This is generally sufficient to melt the thermal interface material 910 and wet the back side 940 and the heat sink 600 to produce the necessary thermal coupling between the heat producing component 130 and the heat sink 600. The above-mentioned exposure times and temperatures can be easily changed/adjusted in a typical wave-soldering machine to suit the requirements of a particular process.

Method 1110 as shown in Figure 11, includes attaching the heat sink 600 in a fixed position on to the heat producing component 130 and the substrate 140 by soldering the at least one pin 510 to the substrate 140 while the thermal interface material 910 is still hot. In some embodiments, the attaching the heat sink 600 in a fixed position includes placing the heat sink 600 in a fixed position on to the heat producing component 130 and the substrate 140 by soldering the at least one pin 510 to the substrate 140 to form solder joints 1120. Soldering the pins 510 locks in the thermal coupling established by the wetting of the thermal grease 910 during the preheating to provide a low-cost thermal solution to the heat producing component 130. In some embodiments, soldering the pins onto the substrate includes wave soldering the at least one pin 510 to the substrate 140 to mechanically attach the heat sink 600 to the substrate 140.

Method 1210 as shown in Figure 12, includes cooling the soldered pins to mechanical fix the heat sink 600 in-place to form the solder joints 1120 and to further lock-in the thermal coupling established between the back side 940 of the heat producing component 130 and the heat sink 600 while the thermal interface material 910 is still hot.

Figures 13, 14, and, 15 illustrate top view 1300, side elevational view 1400, and front elevational view 1500, respectively, of an electronic device including assembled substrate 140 including the heat sink 500 thermally bonded to the heat producing component 130 using the process described with reference to Figures 9, 10, 11, and 12. The process of coupling the heat sink 500 to the heat producing component 130 according the present invention is described in more detail with reference to Figures 9, 10, 11, and 12. It can be envisioned that more than one heat producing component can

be sandwiched between the substrate 140 and the heat sink 500 and further the heat sink can be thermally bonded to more than one heat producing component using the process described with reference to Figures 9, 10, 11, and 12. Although not shown in Figures 13, 14, and 15, it can be envisioned that an air movement device, such as a fan can be mounted on the heat sink 500 to further enhance heat dissipation from the heat sink 500. In some embodiments, the heat producing component 130 is a integrated circuit device such as a chipset, a microprocessor, a digital signal processor, and/or an application-specific integrated circuit device.

Figures 16 and 17 illustrate the coverage/wetting of the thermal interface material on the heat sink side 1600 and the heat producing component side 1700 after passing through the wave pre-heaters. Figure 16 illustrates the thermal interface material coverage after passing through the wave pre-heaters on the heat sink side 1620. Also shown in Figure 16 in dotted line is the outline of the original thermal paste 1610 disposed between the heat sink 500 and the heat producing component 130 before passing through the wave pre-heaters. Figure 17 illustrates the thermal interface material 910 coverage after passing through the wave pre-heaters on the heat producing component 130 side 1710. It can be seen from Figures 16 and 17 that the thermal interface material 910 has completely wetted the heat producing component 130 and has spread beyond the outline of the originally disposed thermal paste 1610 after passing through the wave pre-heaters in a typical wave soldering machine.

Conclusion

The above-described method and device provides, among other things, a low-cost thermal solution by thermally coupling a heat producing component with a heat sink during the pre-assembly operation.